Harmful Algal Blooms

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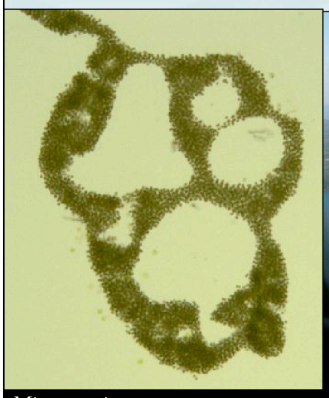
Oceans & Human Health Initiative
Center of Excellence for Great Lakes and Human Health

Concerns

- Degrade water quality (hypoxia, taste/odor, recreational value)
- Alter food webs (large amount of biomass; often not grazed)
- Toxin production (neurotoxins, hepatotoxins, dermatotoxins)

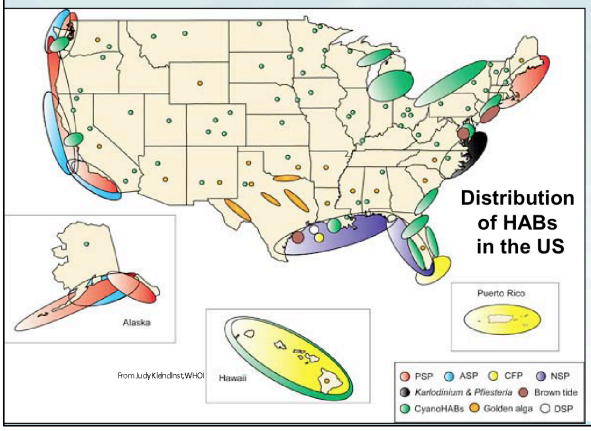


Microcystis sp.

Legislative Mandate

Harmful Algal Bloom and Hypoxia Research and Control Act

Mandate for NOAA to advance scientific understanding and ability to detect, monitor, assess, predict, control, and mitigate HABs and hypoxia events



1998
- First authorized by Congress

2004
- Reauthorized and expanded

2010
- HABHRCA 2004 expires
- House passed HABHRCA 2010
- Senate vote in Fall

- HABHRCA, originally enacted in 1998 and reauthorized in 2004, authorized funding and mandated the National Oceanographic and Atmospheric Administration (NOAA) establish a harmful algal bloom and hypoxia research and control program for water bodies within their purview, the oceans, estuaries and the Great Lakes. The intent of the FHAB Act, now included in HABHRCA 2010, is to authorize funding and mandate the U.S. Environmental Protection Agency (EPA) establish a harmful algal bloom and hypoxia research and control program for water bodies within their purview, all freshwater bodies in the U.S.
- HABHRCA 2010 is needed to continue the NOAA research programs, and mandate that the EPA establish a National Freshwater Harmful Algal Blooms and Hypoxia Research and Control Program so that Federal policy can be developed.

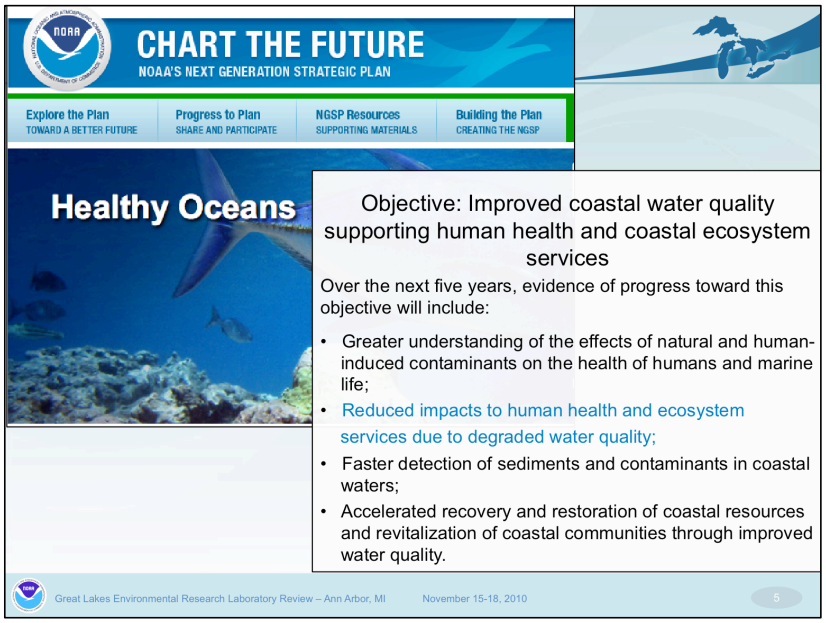


CHART THE FUTURE
NOAA'S NEXT GENERATION STRATEGIC PLAN
Explore the Plan
TOWARD A BETTER FUTURE
Progress to Plan
SHARE AND PARTICIPATE
NGSP Resources
SUPPORTING MATERIALS
Building the Plan
CREATING THE NGSP
Healthy Oceans
Objective: Improved coastal water quality supporting human health and coastal ecosystem services
Over the next five years, evidence of progress toward this objective will include:
• Greater understanding of the effects of natural and human-induced contaminants on the health of humans and marine life;
• Reduced impacts to human health and ecosystem services due to degraded water quality;
• Faster detection of sediments and contaminants in coastal waters;
• Accelerated recovery and restoration of coastal resources and revitalization of coastal communities through improved water quality.
Great Lakes Environmental Research Laboratory Review – Ann Arbor, MI
November 15-18, 2010
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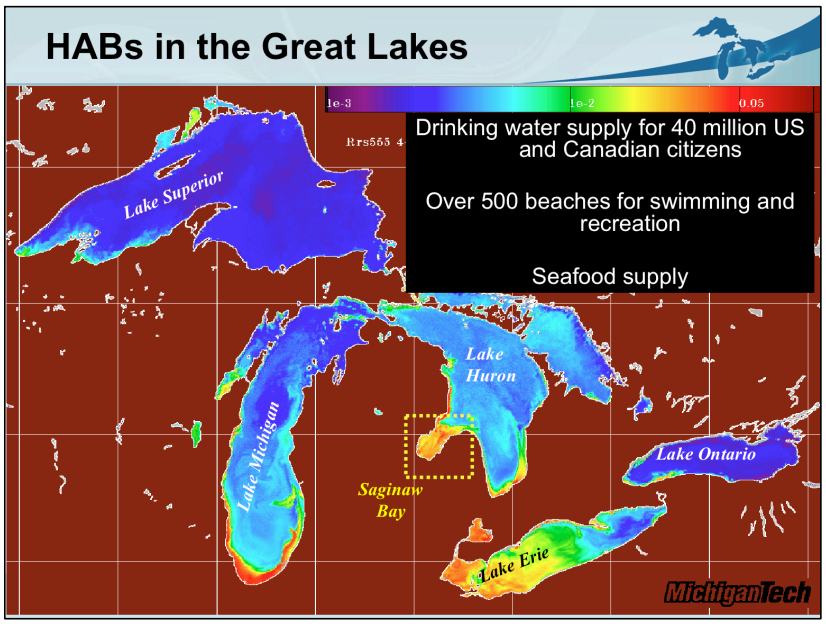
HABs in the Great Lakes
1e-3
1e-2
0.05
Rrs555 4
Drinking water supply for 40 million US and Canadian citizens
Over 500 beaches for swimming and recreation
Seafood supply
Lake Superior
Lake Huron
Lake Michigan
Lake Ontario
Saginaw Bay
Lake Erie
MichiganTech

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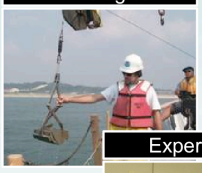
Goals

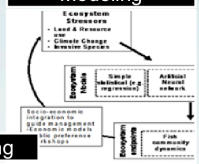
1. Understand the ecological factors controlling bloom growth and toxicity
2. Develop to capacity to detect and predict toxic HAB blooms in order to protect human health

Limnological

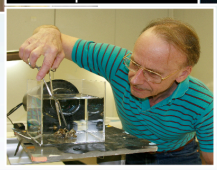


Molecular

Modeling



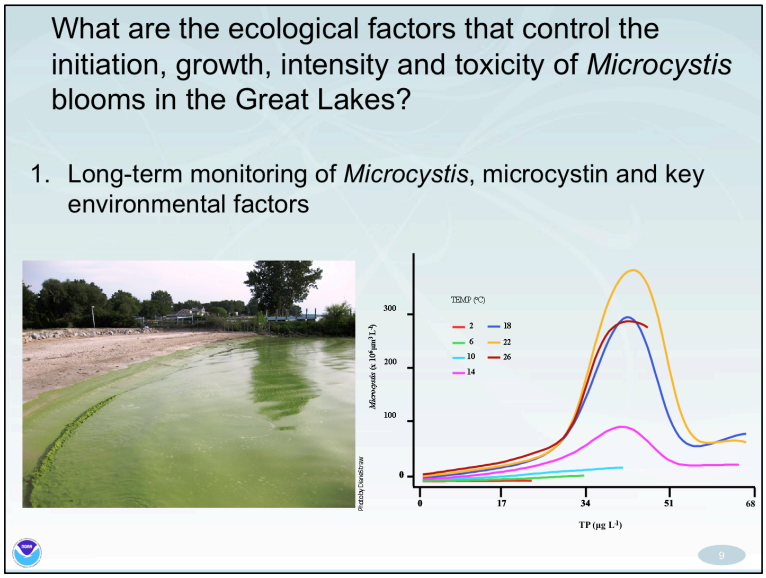
Experimental



Remote sensing

Key Scientific Questions

1. What are the ecological factors that control the initiation, growth, intensity and toxicity of *Microcystis* blooms in the Great Lakes?
2. What is the potential for human exposure to cyanotoxins in the Great Lakes?
3. How do we protect human and ecological health from the impacts of HABs in the Great Lakes?



Publications for Project 1:

Fahnenstiel, G.L., Millie, D.F., Dyble, J., Litaker, R.W., Tester, P.A., McCormick, M.J., Rediske, R. and D. Klarer. 2008. Factors affecting microcystin concentration and cell quota in Saginaw Bay, Lake Huron. *Aquatic Ecosystem Health and Management,* 11:190-195.

Dyble, J, Bienfang, P., Dusek, E., Griffiths, W., Holland, F., Hitchcock, G., Laws, E., Lerczak, J., McGillicuddy, D.J., Minnett, P., Moore, S., O'Kelly, C., Solo-Gabriele, H., and J. Wang. 2008. Environmental controls, oceanography and population dynamics of pathogens and harmful algal blooms: Connecting sources to human exposure. *Environmental Health.* 7(suppl 2): S5.

Millie, D. F., Pigg, R., Tester, P. A., Dyble, J., Litaker, R. W., Carrick, H. J. & Fahnenstiel, G. L. 2006. Modeling phytoplankton abundance in Saginaw Bay, Lake Huron: using artificial neural networks to discern functional influence of environmental variables and relevance to a Great Lakes Observing System. *J. Phycol.* 42: 336–349.

Millie, D.F., G.L. Fahnenstiel, J. Dyble, R. Pigg, D.M. Klarer, R.W. Litaker, and P.A. Tester. 2008. Influence of environmental conditions on late-summer cyanobacterial abundance in Saginaw Bay, Lake Huron. *Aquatic Ecosystem Health and Management Society* 11: 196-205.

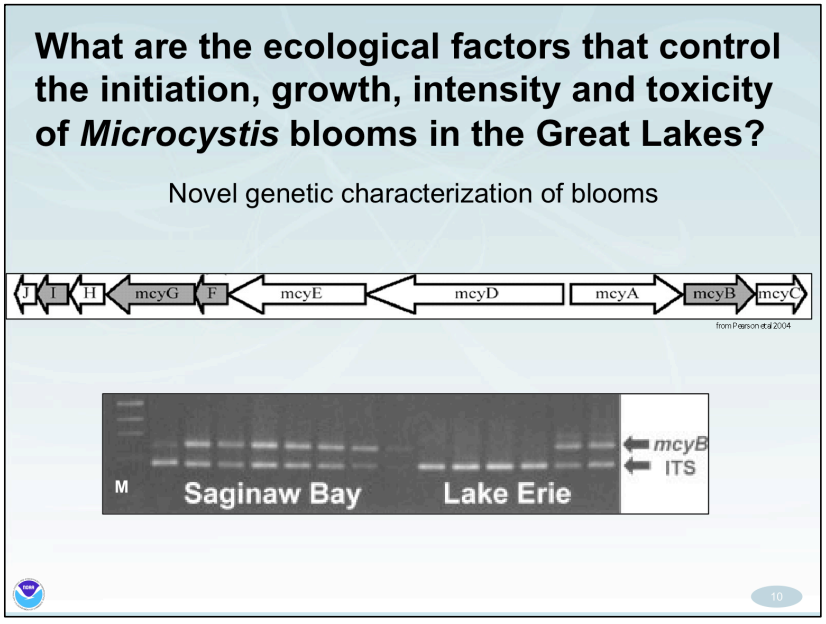
Millie, D.F., Fahnenstiel, G.L., Dyble, J., Pigg, R.J., Rediske, R.R., Klarer, D.M., Tester, P.A., and R.W. Litaker. 2009. Late-summer phytoplankton in western Lake Erie (Laurentian Great Lakes): bloom distribution, toxicity and environmental influences. *Aquat. Ecol.* 43: 915-934.

Millie, D.F., Fahnenstiel, G.L., Weckman, G.R., Klarer, D.M, Dyble, J., Vanderploeg, H.A., and D. Fishman. 2010. An 'Enviro-Informatic' assessment of Saginaw Bay (Lake Huron USA) phytoplankton: Data-driven characterization and modeling of *Microcystis* (Cyanophyta), *J. Phycol.* accepted.

Posters for Project 1:

An 'Enviro-Informatic' assessment of Saginaw Bay (Lake Huron USA) phytoplankton: Characterization and modeling of *Microcystis*

Statistical modeling approaches for identifying biotic and abiotic factors with high correlation to *Microcystis* abundance (Fahnenstiel *et al.*)



Microcystin production is controlled by a bi-directionally transcribed operon consisting of 10 genes (*mcyA* – *mcyJ*). Most of our research uses the *mcyB* gene.

The figure gives representative results from multiplex PCR using PCR primers for *Microcystis* ITS and *mcyB*. The presence of the smaller (530 bp) ITS (internal transcribed spacer region between the 16S and 23S genes) PCR product indicates that the colony is *Microcystis* and the DNA is not degraded. The presence or absence of the larger (800 bp) *mcyB* PCR product indicates whether this colony is capable of microcystin production. The molecular weight marker (M) is a phi X-174RF HaeIII digest.

Publication for Project 2:

Dyble, J., Fahnenstiel, G.L., Litaker, R.W., Millie, D.F., and P.A. Tester. 2008. Microcystin concentrations and genetic diversity of *Microcystis* in the lower Great Lakes. *Environmental Toxicology* 4:507-516.

Posters for Project 2:

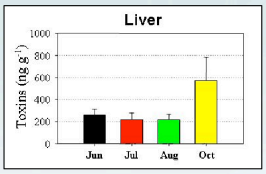
Applying novel molecular biological tools in detection and prediction of cyanobacterial harmful algal blooms

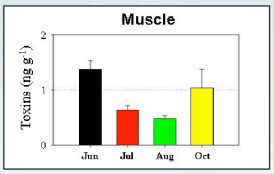
Experimental assessment of the role of dreissenid mussels in promoting *Microcystis* blooms and toxin production (Dyble, Vanderploeg *et al.*)

What is the potential for human exposure to cyanotoxins in the Great Lakes?

2) Field and lab studies of microcystin accumulation in fish

Yellow perch, *Perca flavescens*





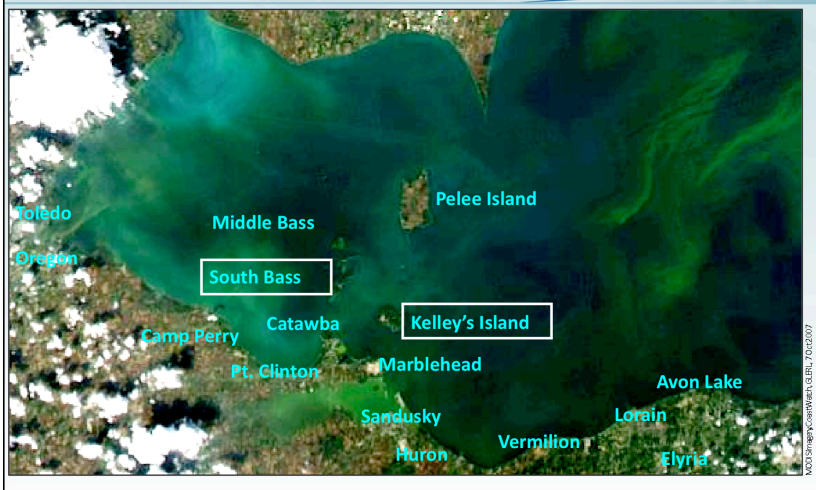
Western Lake Erie perch (2006)

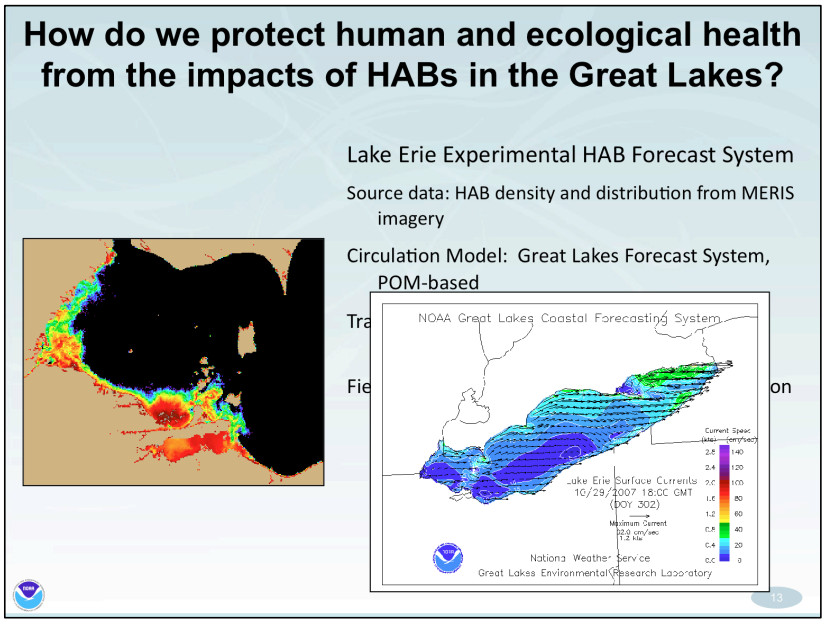
Conservative limit for microcystin in fish tissues:
9.5 ng microcystin g^{-1}

2) Microcystin in drinking water supplies of Lake Erie island communities

Publication for Project 1:
Wilson, A.E., Gossiaux, D.C., Hook, T.O., Berry, J.P., Landrum, P.F., Dyble, J. and S.J. Guildford. 2008. Evaluation of the human health threat associated with the hepatotoxin microcystin, in the muscle and liver tissues of yellow perch *(Perca flavescens)*. *Canadian Journal of Fisheries and Aquatic Science* 65:1487-1497.

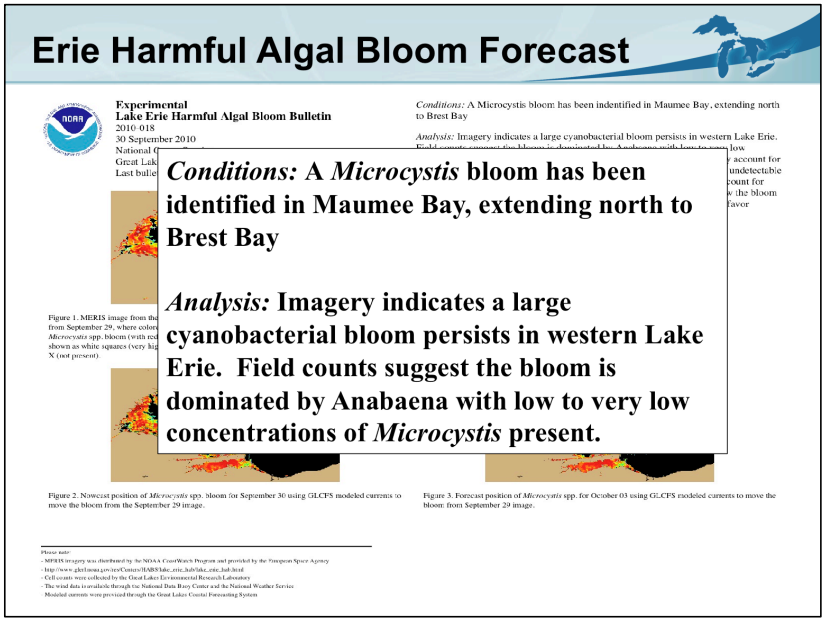
Lake Erie as Drinking Water Supply





HAB density and distribution from MERIS imagery: Wynne, T., Stumpf, R., Tomlinson, M., Warner, R., Tester, P., Dyble, J. and G. Fahnenstiel. 2008. Relating spectral shape to cyanobacteria blooms in the Laurentian Great Lakes. *International Journal of Remote Sensing* 29:3665-3672.

Circulation Model: Great Lakes Coastal Forecasting System, Princeton Ocean Model (POM)- based: SCHWAB, D. J., and K. W. Bedford. The Great Lakes Forecasting System. *Coastal Ocean Prediction, Coastal and Estuarine Studies* 56, C.N.K. Mooers (Ed.), American Geophysical Union, Washington, DC, pp. 157-173 (1999).



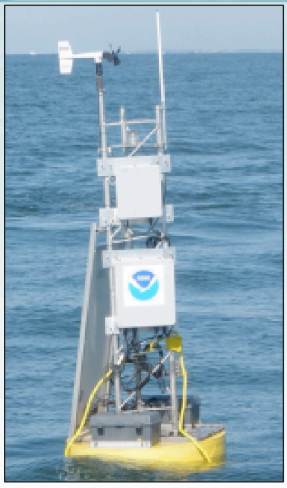
Users of Lake Erie HAB Bulletin

- **Lake Erie Water Utilities**: Toledo, South Bass Island, Kelley's Island, Cleveland, American Water, NE Ohio Regional Sewer District
- **Health Departments**: Monroe, Toledo, Port Clinton
- **Beach Managers**: Cleveland Metro Parks
- **State and City Governments**: Ohio DNR, Ohio EPA, Cities of Huron, Monroe, Sandusky, Lorain, Oregon, Cleveland, Luna Pier
- **Academics**: University of Toledo, University of Michigan, Heidelberg University
- **Private Citizens**

Photo: L. Merchant/Kevin Kirke

Future Work

- Real time data from buoy-based sensors
  - nutrients
  - phycocyanin, chlorophyll *a*
  - microcystin
  - *Microcystis*-specific molecular probes
- Ecological model to better predict bloom dynamics and toxicity – part of HAB forecast
- Operational HAB forecast for western Erie and Saginaw Bay (Lake Huron)
- Continue to combine genetic and ecological approaches to better understand HAB growth and toxicity



Questions?

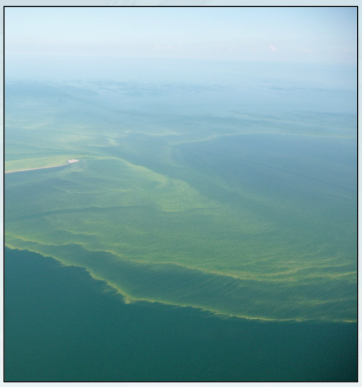


Photo by Tom Archer